**Voltage Valley Settlement Project**

*A problem based learning unit for 4th and 5th grade math, science, and engineering*

Target Grade Level(s): 4-5

Subject(s): Science, Math

Author(s): Lauren Howze, Brandy Schroeder, Grace Lefebure, Michelle Riske, Heather Uhler, Sheila Dorst

**Problem Statement:**

Just as the Builders created the City of Ember to escape impending disaster, the U.S. Department of Energy (DOE) is working to reduce the world’s dependence on non-renewable resources like fossil fuels. When non-renewable resources ran low in the City of Ember, Lina and Doon chartered the course for starting a new life in a new place. Similarly, the DOE has selected a smart group of students (your class) to pioneer a new city that runs on only renewable energy sources. The class will work together in small groups to achieve this goal before fossil fuels run out. For this project you will explore the available land to decide the best location for your client family’s home based on their energy, recreational, and career needs and wants. As part of your learning, you will be completing a builder’s book to demonstrate your understanding of various renewable energy sources and the methods to transform those energy sources into usable electricity.

\*\* This PBL is based upon students reading the book *City of Ember.* This unit can be taught without the reference with slight modification of the problem statement.

Your completed proposal shall consist of two parts:

Part 1: Builder’s Book

* Background of the six types of renewable energy
* Circuit certification
* Power certification (wattage)
* Power transfer certification
* Power requirements
* Family needs and wants

Part 2: Homestead Proposal

* The chosen location of your homestead
* The renewable energy resources available at your homestead and how you will harness those resources
* The cost benefits and justification for the energy sources you choose

**Unit Overview and Table of Contents**

In this PBL unit, students will apply knowledge about renewable energy sources to plan and develop a homestead proposal based on harnessing renewable energy in a chosen location. Students will explore a map to decide where to settle based on the resources that they would like to use in their homes. As part of their learning, students will complete a series of certifications that will demonstrate their understanding of renewable energy sources, energy transfers, and a cost benefit analysis of their energy needs.

Before beginning this PBL students should:

1. Have a basic understanding of non-renewable vs. renewable energy sources
2. Have an in depth understanding of hydro, wind, and solar energy
3. Have a basic understanding of input and outputs of systems
4. Have a basic understanding of energy transfers

\*\* Teachers are encouraged to contact the PUD to serve as experts on wind and hydro energy. The PUD all offers solar energy workshops for teachers’ professional development during summer break. In addition, teachers can contact the University of Washington Sun Dawgs as experts on solar energy. The NEED Project ([www.need.org](http://www.need.org)) has training and free materials available as well.

* Lesson 1: Renewable Energy Jigsaw
* Lesson 2: Circuits and Switches
* Lesson 3: Power
* Lesson 4: Energy Transfer
* Lesson 5: Energy Experiments
* Lesson 6: Energy Requirements
* Lesson 7: Settlement Proposal and Presentation

**Lesson standards (NGSS, CCSS, CTE):**

**NGSS 4PS3-2.** Make observations to provide evidence that energy can be transferred from place to place by sound light, heat, and electric currents.

**NGSS 4ESS3-1.** Science and Engineering Principle (SEP) “Obtain and combine information from books and other reliable media to explain phenomena.

**CCSS Math 4.NBT.** Use place value understanding and properties of operations to

perform multi-digit arithmetic.

**CCSS Math 4.NF.** Understand decimal notation for fractions, and compare decimal

fractions.

**CCSS Math 4.MD.** Solve problems involving measurement and conversion of

measurements from a larger unit to a smaller unit.

**CCSS Math 5.NBT.** Perform operations with multi-digit whole numbers and with

decimals to hundredths.

**CCSS Math 5.NF.7.** Apply and extend previous understandings of multiplication and

division to multiply and divide fractions.

**CCSS Math 5.MD.** Convert like measurement units within a given measurement system.

[**CCSS.ELA-LITERACY.RI.4.1**](http://www.corestandards.org/ELA-Literacy/RI/4/1/)**.** Refer to details and examples in a text when explaining what the text says explicitly and when drawing inferences from the text.

[**CCSS.ELA-LITERACY.RI.4.2**](http://www.corestandards.org/ELA-Literacy/RI/4/2/)**.** Determine the main idea of a text and explain how it is supported by key details; summarize the text.

[**CCSS.ELA-LITERACY.RI.4.3**](http://www.corestandards.org/ELA-Literacy/RI/4/3/)**.** Explain events, procedures, ideas, or concepts in a historical, scientific, or technical text, including what happened and why, based on specific information in the text.

[**CCSS.ELA-LITERACY.RI.5.**](http://www.corestandards.org/ELA-Literacy/RI/5/2/)**2.** Determine two or more main ideas of a text and explain how they are supported by key details; summarize the text.

[**CCSS.ELA-LITERACY.RI.5.7**](http://www.corestandards.org/ELA-Literacy/RI/5/7/)**.** Draw on information from multiple print or digital sources, demonstrating the ability to locate an answer to a question quickly or to solve a problem efficiently

[**CCSS.ELA-LITERACY.RI.5.8**](http://www.corestandards.org/ELA-Literacy/RI/5/8/)**.** Explain how an author uses reasons and evidence to support particular points in a text, identifying which reasons and evidence support which point(s).

[**CCSS.ELA-LITERACY.W.5.1.A**](http://www.corestandards.org/ELA-Literacy/W/5/1/a/)**.** Introduce a topic or text clearly, state an opinion, and create an organizational structure in which ideas are logically grouped to support the writer's purpose.

[**CCSS.ELA-LITERACY.W.5.1.B**](http://www.corestandards.org/ELA-Literacy/W/5/1/b/)**.** Provide logically ordered reasons that are supported by facts and details.

[**CCSS.ELA-LITERACY.W.5.1.C**](http://www.corestandards.org/ELA-Literacy/W/5/1/c/)**.** Link opinion and reasons using words, phrases, and clauses (e.g., consequently, specifically).

[**CCSS.ELA-LITERACY.W.5.1.D**](http://www.corestandards.org/ELA-Literacy/W/5/1/d/)**.** Provide a concluding statement or section related to the opinion presented.

**Soft Skills:**

**21st Century Skills: Content Knowledge and 21st Century Themes.** Mastery of fundamental subjects and 21st century themes (i.e., Environmental Literacy) is essential for students in the 21st century.

**21st Century Skills: Information, Media, and Technology.** Today we live in a technology and media-suffused environment with: 1) access to an abundance of information, 2) rapid changes in technology tools, and 3) the ability to collaborate and make individual contributions on an unprecedented scale. To be effective in the 21st century, citizens and workers must be able to create, evaluate, and effectively utilize information, media, and technology.

**Connections to career and educational pathways:**

This unit introduces the students to several career pathways, including:

1. Civil Engineer - selecting build site, building structures, and working with a client
2. Mechanical Engineer - developing hardware for renewable energy technology
3. Chemist/Chemical Engineer - engineering renewable energy technology
4. Electrical Engineer - developing electronics for renewable energy technology
5. Consultant - managing client relationships

**Lesson 1: Building Background for Renewable Energy**

**Renewable Energy Jigsaw**

**Problem statement:** As part of your learning to get ready for your client’s estate proposal, you will be completing a builder’s book that will help you make decisions for your client’s housing and energy needs. In your builder’s book, you will need to demonstrate an understanding of various renewable energy sources and the methods to transform those energy sources into usable electricity. In this lesson, you will collect background information about several types of renewable energy sources for the builder’s book.

**Learning objectives:**

* Students will conduct brief, focused research in order to define and describe forms of energy and how they may affect the environment using a jigsaw as a cooperative learning strategy.

**\*\* Nuclear Energy will not be covered in jigsaw (may want to preface/prepare students).**

* The students will also brainstorm effective group work skills and develop an energy foldable for their builder’s book, which is a reference tool for completing the PBL.

**Lesson standards (NGSS, CCSS, CTE):**

**NGSS 4PS3-2.** Make observations to provide evidence that energy can be transferred from place to place by sound light, heat, and electric currents.

**NGSS 4-ESS3-1.** Science and Engineering Principle (SEP) “Obtain and combine information from books and other reliable media to explain phenomena.”

[**CCSS.ELA-LITERACY.RI.5.**](http://www.corestandards.org/ELA-Literacy/RI/5/2/)**2**. Determine two or more main ideas of a text and explain how they are supported by key details; summarize the text.

[**CCSS.ELA-LITERACY.RI.5.7**](http://www.corestandards.org/ELA-Literacy/RI/5/7/)**.** Draw on information from multiple print or digital sources, demonstrating the ability to locate an answer to a question quickly or to solve a problem efficiently

**CCSS. ELA- LITERACY.W7.** Conduct short as well as more sustained research projects based on focused questions, demonstrating understanding of the subject under investigation.

[**P21 Soft Skills**](http://www.p21.org/about-us/p21-framework):

Information Literacy: Access information efficiently (time) and effectively (sources); Use information accurately and creatively for the issue or problem at hand.

ICT Literacy: Use technology as a tool to research, organize, evaluate and communicate information.

**Materials:**

* Large T-Chart of what effective group work looks and sounds like
* Jigsaw fact sheets
* NEED Elementary Energy Infobook
* Computer/Tablet
* Popsicle sticks with 6 renewable energy types written on them
* Foldable powerpoint template of jigsaw for the Builder’s Book
* Online Articles:
  + Energyquest.ca.gov/story/index.html
* Online Videos:
  + <https://www.youtube.com/playlist?list=PLACD8E92715335CB2> (Energy 101)

**Lesson preparation:** Print set of jigsaw fact sheets (1 of each renewable energy type per group), set of maps (1 per table), foldable template (1 per student), cost sheet (1 per table)

**Time required:** 2-3 45 minute time periods for research; 1 or 2 45 minute periods for product creation and jigsaw.

**Grouping of students for instruction:**

Teachers will group students according to their preference. Groups of 6 or more are optimal. Each group needs an expert in each energy source included in your unit.

**Grouping Options**

* Students will be placed in table teams as their company groups. The teacher will hand the group a cup with the popsicle sticks with 6 renewable energy types written on them and each member will pull a popsicle stick to determine their expert groups.
* Student picked by topic interest
* Teacher picked
* Randomly grouped

**Understanding the Problem**

|  |  |
| --- | --- |
| **Teacher** | **Student** |
| Set group norms. | Brainstorm and share ideas to contribute to class norms. |
| Describe PBL problem statement and how this lesson fits into the builder’s book. | Listen and ask clarifying questions. |
| Explain to the students that they will be participating in a jigsaw activity, moving from company groups to expert groups. Each expert group will research a renewable resource and record answers on fact worksheets. They will then return to their company groups and share what they learned.   * Option 1: expert groups explore all available resources and self regulate * Option 2: expert groups rotate through stations (maps, articles, book, video, etc.) and explore one medium at a time | Listen and ask clarifying questions. |
| Identify company groups (as defined above). Tell the students that with the exception of the jigsaw, they will be working in their company groups to complete other certifications. | Reflect on group norms. |
| Select expert groups: Once the company groups are identified, the teacher will tell the students that they will need one member to become an energy expert for each of the 6 renewable energies studied. Teacher will have a cup with sticks with each renewable energy identified on a stick. (one stick per energy) | Students will be in their company groups and will draw a stick from the cup to determine their energy group. |
| Teacher will review the jigsaw question packet for each renewable resource.  Teacher will then introduce available resources for the jigsaw. This will include a map, an energy graph, websites, a student text and videos specific to the renewable energy students are studying.  Teacher will then excuse students to move to their energy expert groups. (Depending on the option choose from above).  Once students are in their expert groups, the teacher will instruct the students to brainstorm a way for their expert group to be productive in their research. (For instance, go over all the questions together, spend some time reading individually the resources and jotting down ideas before sharing, etc.) | Listen and ask clarifying questions. Once students move into their energy groups, they can begin the jigsaw.  Students will determine groups work protocol amongst themselves and begin research. |
| Teacher circulates the classroom to facilitate groups as needed. Allow time for groups to explore resources and work on jigsaw questions. | Students will explore available resources and fill out jigsaw packet for expert group. |
| Once students have completed their jigsaw question packet, have the students work together to discuss their findings in their expert groups. | Students will share knowledge learned with teammates in expert group.  Energy experts will work together to ensure that they have similar findings within their questions. (Text-based evidence) |
| Through the use of google classroom or some other form of technology available to the teacher, the teacher will distribute the builder’s book template to all energy expert groups.  The teacher will go over the aspects of the template. Then instruct the energy experts to create a jigsaw on their energy that they will bring back to their company teams. | Students will discuss group skills and reflect on learning.  Students will work individually on synthesizing their information and create a page for their builders book to bring back to their company teams. |
| Once students have completed their jigsaw builders book, then the teacher will instruct students to go back their company groups and share out their pages created. They will then insert them into the builder’s book. (Each expert from their company will share their energy and then attach it to their group book) | Students will share learning with their company teams and attach it to their builder’s book. |
| Teacher will collect and assess based on the rubric. Provided in order to allow for jigsaw certification of the book for their company teams. | Students will turn in the company builder’s book for certification and grading. |

**Accommodations:** Teacher can upload the questions into Google Drive if it is easier for students to type their responses rather than hand write. The NEED project has alternative leveled text complexity for students needs.

**Extensions:** The fact worksheets have bonus questions to explore once the primary information has been collected.

**Assessment:** The students will use the knowledge they collect from the jigsaw activity to fill out the energy background panel in their builder’s book. Successful completion of the builder’s book is the foundation for the final proposal.

**Lesson 2: Circuits and Switches**

**Problem statement:**

In this lesson you will be working on your circuit certification for your builder's book. Electricity is an energy source that we depend on every minute of the day. In this lesson, you will begin to develop an understanding of electrical currents and circuits, and will begin to answer the questions: what is electricity, what is an electrical current, and what is an electrical circuit.

**Learning objectives:**

* Students will be able to create a simple circuit.
* Students will be able to model a simple circuit using a schematic drawing.
* Students will be able to explain why standard symbol systems, like schematic diagrams are important.
* Students will be able to explain how to tell when the path of an electric circuit is complete.

**Lesson standards (NGSS, CCSS, CTE):**

**NGSS 4. PS3-2.** Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric current.

**NGSS 4-PS3-4.** Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.

**Soft Skills**

21st Century Skills: Communication and Collaboration

* + Demonstrate ability to work effectively and respectfully with diverse teams
  + Exercise flexibility and willingness to be helpful in making necessary compromises to accomplish a common goal
  + Assume shared responsibility for collaborative work, and value the individual contributions made by each team member

**Connections to career and educational pathways**

[Influence of Engineering, Technology, and Science on Society and the Natural World](http://www.nap.edu/openbook.php?record_id=13165&page=212)

* [Over time, people’s needs and wants change, as do their demands for new and improved technologies. (4-ESS3-1)](http://www.nap.edu/openbook.php?record_id=13165&page=212)
* [Engineers improve existing technologies or develop new ones. (4-PS3-4)](http://www.nap.edu/openbook.php?record_id=13165&page=212)

**Materials:**

* Circuit sticks
* Schematic diagram symbols Key for students
* Schematic diagram Teaching Tool

*Each student group will need:*

* 1 bulb (1.5-5.0 volts)
* 1 D-Cell Battery
* 8 “length of insulated wire with both ends stripped

*Optional For Builders Book Certification Page (Each student will need. All items can be found on Amazon; prices are estimated below)*

* *¼ inch Copper tape ($15)*
* *LED light (300 for $10)*
* *CR 1220 3 volt battery (5 for $6)*

*Enrichment Activities*

* Notecards (any size will work)
* 2 Brass Brackets
* Paperclip

**Lesson preparation:**

1. Plan to have students work in groups of three
2. Cut two 8” wire pieces for each group and strip ends
3. Prepare group materials in a resealable plastic bag

**Time required:**

**Part One-** 1 hour

**Part Two-** 1 hour

**Grouping of students for instruction:**

Students will be grouped in pairs or groups of three.

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| **Teacher Actions** | **Student Actions** |
| **Introduction:**  The teacher will introduce circuits by engage students using a circuit stick. The teacher will ask students to stand in a circle holding hands. The teacher will ask different students to unclasp their hands.  The teacher will direct a class discussion.  *What did you notice when someone unclasps their hands?*  *When does the circuit work?*  *What might this tell us about circuits?*  The teacher will record student observations. | Students will make observations when the circuit stick is working and when it is closed. |
| **Part One: Exploration of Circuits**  The teacher will explain that the students will have a chance to create their own working circuit. Students will be broken into groups of three and given a wire, battery, and light bulb. The teacher will explain that students will be given time to try making their own circuit light using the information gathered by the opening activity. The teacher will encourage students to look for multiple ways to create a working circuit.  The teacher will bring students together and have a few groups share the circuits they created.  The teacher will ask students to reflect on what all the working circuits have in common.  The teacher will ask students to brainstorm based on their observations what might be required to have a working circuit. | Students will work with group to explore and discover different ways to light the bulb.  Students will share circuits they created  Students will share and participate in class discussion |
| The teacher will connect students brainstormed ideas to the concept of open and closed circuits.  The teacher will explain that circuits are a closed path for electricity. Refer to the first activity. All hands must be connected to make the make the light go off.  The teacher will explain that open circuit means that there is a piece missing in the electricity's pathway that stops the electricity from making it completely around the circuit.  *The teacher can introduce latin root circ- means to go around. When the path is broken it it is an open circuit and the electricity cannot go all the way around, but when the circuit is closed the electricity can make it all the way around.*  The teacher will explain that all circuits have 3 main parts: a power source, a conducting path, and a load (the item that will use the electricity)  The teacher will ask students to identify the power source, conducting path, and load in the circuits they’ve created. | Students will participate in class discussion. |
| **Part Two: Schematic Drawings and Certification**  The teacher will hand out the ***Schematic Diagram hand out***. The teacher will introduce the concept that electricians and professionals that work with circuits use special symbols to model the circuits they create. These symbols allow for people to have a universal language so that everyone can understand a given circuit.  The teacher will introduce symbols using the handout, and model for students using a student created circuit, from the previous exploration, how to represent it using the schematic symbols.  The teacher will then introduce the certification activity.  Student groups will be given an additional wire and be asked to create a working circuit and draw the corresponding schematic diagram. Students will have both pieces certified by the teacher.  *Optional Certification: Once certified, students will be given their Builder’s Book Certification page. Individually, students will recreate their groups two wired circuit using copper tape, an LED light bulb, and 3 volt battery (A template can be found in the student resources for this lesson)*  *If the teacher decides to skip optional certification students will create an individualized final draft of their schematic diagram in their builders book.*  The teacher will lead students in reflection of their circuit:   1. What were the different parts of your circuit? 2. Was the circuit complete or incomplete? How did you know?   The teacher can use assessment and rubric to gage students understanding of circuits. | Students will participate in class discussion.  Students will work with groups to create a 2 wire circuit and schematic drawing.  Students will work on their finalized and individual certification page for their builders book. |

**Accommodations:** Teacher can also provide students with the *Will the Circuit Light* handout and have them test and build these circuits. Once students have tested the different schematic diagrams, they can draw conclusions on the important parts of a working circuit.

**Extensions:** Parallel circuits- spend some time exploring both schematic diagrams of parallel circuits and the role of switches in parallel circuits. A parallel circuit is a closed circuit where the electrical current is divided into two or more paths before recombining to complete the circuit. Students can explore how the brightness changes dependent on the number of power sources or the setup of the circuit. You can also have students use multiple switches and explore the effect on the light bulbs.

A switch can be made using two brackets, a paper clip, and a note card.

**Switch Example:**



**Parallel Circuit Option One: Series Circuit Option Two:**



Introduce Electricity Concepts-

Amps-the rate of flow of electrons (electrical current). Can use the idea of flowing water in a pipe.

Volts- a device, such as a battery, provides potential difference in an electric circuit. The battery is the water pump that propels the water through a pipe. It creates pressure in the pipe causing the water to flow. This electrical pressure is measured in Volts. The bigger the voltage the higher the pressure and the more the current flows (provide students with the explanation that volts are coming from you energy source and give students different examples of voltage from different size batteries).

**Assessment:**

Formative Assessment in the Lessons- Circuit Drawings

Formative Assessment- Builders Book Circuit Page- drawing and explaining a working circuit

**Lesson 3: Power**

**Problem Statement**

Before choosing the ideal location for your client, you first need to understand how much power your client's house will require. Electrical devices each have a unique power requirement, and the total power requirement of a system, like a house, is referred to as electrical load. You will add a section to the builder’s book about power to demonstrate your understanding of this concept.

**Learning Objectives**

Students will…

1. Understand the relationship between electrical energy and power.
2. Understand the mathematical relationship between power and circuits.
3. Understand conversions from one unit of power to another.
4. Understand the monetary cost of using electrical devices.

**Lesson standards (NGSS, CCSS, CTE):**

**NGSS 4PS3-2.** Make observations to provide evidence that energy can be transferred from place to place by sound light, heat, and electric currents.

**NGSS 4ESS3-1**. Science and Engineering Principle (SEP) “Obtain and combine information from books and other reliable media to explain phenomena. “

**CCSS MATH 4.NBT.** Use place value understanding and properties of operations to

perform multi-digit arithmetic.

**CCSS MATH 4.NF.** Understand decimal notation for fractions, and compare decimal

fractions.

**CCSS MATH 4.MD.** Solve problems involving measurement and conversion of

measurements from a larger unit to a smaller unit.

**CCSS MATH 5. NBT.** Perform operations with multi-digit whole numbers and with

decimals to hundredths.

**CCSS MATH 5. NF.** Apply and extend previous understandings of multiplication and

division to multiply and divide fractions.

**CCSS MATH 5. MD.** Convert like measurement units within a given measurement system.

[**CCSS.ELA-LITERACY.RI.5.7**](http://www.corestandards.org/ELA-Literacy/RI/5/7/)**.** Draw on information from multiple print or digital sources, demonstrating the ability to locate an answer to a question quickly or to solve a problem efficiently

**Materials**

* Calculator
* Power Packet
  + Power Consumption of Common Household Items Handout
  + Calculating Power Requirements Worksheet
  + Energy Label Worksheet
  + Power Conversion Worksheet
  + Total Electrical Load of a House Worksheet
  + Cost of Power Worksheet
* Power foldable template

**Lesson Preparation**

Print a class set of the power packet.

**Time Required**

1 hr - time breakdown in instruction section.

**Grouping of Students for Instruction**

Students will complete the power packet individually. Students will work in their family group (as described in Lesson 1) to fill out the power foldable template for their builder’s book.

**Instruction**

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| --- | --- |
| **Teacher** | **Student** |
| Open Electrical Power Lesson presentation. | Listen. |
| Give overview of electrical power (slide 2).   * Electric power is the rate at which electrical energy is transferred through a circuit per unit time. * Electrical devices each have a unique power requirement, and the total power requirement of a system, like a house, is referred to as electrical load. * The power company bills the residents of a house by the electrical load they are using. | Listen and ask clarifying questions. |
| Review power requirements for common appliances (slide 3). Students can refer to the first page of their power packet to find a more in depth list for discussion.  Teacher can have student discuss with their groups different appliances they use at home and their differing amounts of energy needs. | Review, compare, and discuss power requirements for common appliances (5min). |
| Describe how electrical power is related to circuits and calculated using  Current x voltage = power (slide 4).  l x v= p  Explain to students that voltage is supplied from our power outlets and in the U.S. we have outlets that supply 120 volts.  For an extension you can discuss different volts found around the world and the adaptations made to electrical appliances to make sure they work properly. | Complete Calculating Power Requirements Worksheet in packet (5min). |
| Describe how to read energy labels (slide 5). | Answer the question on the Energy Label Worksheet (5min). |
| Describe different units of power, including how to convert watts to kilowatts (slide 6).  Teacher can draw connection to the metric system conversions. Teacher can also reframe equation to dividing powers of 10.  W/103  Teacher may want to lead students in a discussion why KW would be more common that W. | Understand how power and energy are related and complete Power Conversion Worksheet (5min). |
| Share how to calculate the total electrical load of a house (slide 7).  Electrical load: total power requirement  Total need is determined by time of use and the electrical power requirements of each item. | Complete the Total Electrical Load of a House Worksheet (10min). |
| Describe how power is measured and purchased from an electric company (slide 8).   * Measured using an electricity meter * Billed by the kilowatt-hour | Build on the previous example and complete the Cost of Power Worksheet (10min). |
| Distribute computers to students and introduce foldable template and requirements for certification. | Use foldable template to prepare power certification section of builder’s book (20min). |

**Accommodations**

Teacher can adapt numbers to be more accessible for struggling students (using single/double digit whole numbers instead of three digit numbers and decimals). Teacher can also allow struggling students to work with a high level peer or provide struggling students with a calculator.

**Extensions**

The worksheets have bonus questions that can be completed once the primary information is collected.

Have students look at different volts found around the world. Students can do research to see what technology has been created to make sure that appliances manufactured in one country, can still work in another. Students can do research to see the average amount of power consumption for a household and calculate the weekly, monthly, and yearly cost.

**Assessment**

The student’s ability to fill out the questions in the power page of the builder’s book demonstrates their understanding of the material. The teacher will use the rubric to evaluate the power page of the builder’s book and award the “Power Certification.” There is also a teacher guide for power packet guidance and answers.

**Lesson 4: Energy Transfer**

# **Overview**

To use a renewable resource to power your electrical devices, the energy must first be transformed from its natural state into something useful to you in your house. Each type of renewable resource has different variables that will affect the amount of power that is generated. You will learn what those variables are and how to calculate the energy output per day. You will add a section to your builder’s book about energy transfer to demonstrate your knowledge of the concept.

# **Goals & Objectives**

Students will…

1. Understand how energy flows from the power source to the home.
2. Understand how energy is transformed from the native renewable source to electricity at the home.
3. Understand how to calculate the energy output from various sources of renewable resources.

# **Standards**

**NGSS 4. PS3-2.** Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric current.

**NGSS 4-PS3-4.** Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.

**CCSS MATH 4.NBT.** Use place value understanding and properties of operations to

perform multi-digit arithmetic.

**CCSS MATH 4.NF.** Understand decimal notation for fractions, and compare decimal

fractions.

**CCSS MATH 4.MD.** Solve problems involving measurement and conversion of

measurements from a larger unit to a smaller unit.

**CCSS MATH 5. NBT.** Perform operations with multi-digit whole numbers and with

decimals to hundredths.

**CCSS MATH 5. MD.** Convert like measurement units within a given measurement system.

# **Materials**

* Calculator
* Energy Transfer Packet
  + Energy Flow Card Deck
  + Energy Transfer Worksheet
  + Energy Calculation Worksheets
  + Energy Output Graph Template
* Energy Transfer Foldable

# **Lesson Preparation**

Print out Energy Transfer Packet

# **Time Required**

Two 45 minute class periods:

* Energy flow and energy transfer
* Energy output calculations and graph

# **Grouping of Students for Instruction**

Students will work in their consulting companies for the energy flow and energy transfer activities.

Students will work alone to complete the energy output calculations.

Students will work in their company groups to complete the summary table and graph.

# **Instruction**

# *Note: detailed information can be found below T-chart*

|  |  |
| --- | --- |
| **Teacher** | **Student** |
| Give overview of energy flow. (Reference pg 3 of Lesson Plan)  Define and have students record definitions on their note taking sheet.   * Primary Energy * Secondary Energy * Final Energy * Useful Energy | Listen and ask clarifying questions.  Take notes on definitions and examples. |
| Explain energy flow activity. Explain to students they can use their note taking sheet as they play. | Complete the energy flow activity in company groups |
| Give overview of energy transformation. Explain (Reference pg 4 of Lesson Plan) and have students record on their transformation handout.   * Mechanical to electrical transformation * Light to electrical transformation | Listen and ask clarifying questions  Record definitions |
| Explain energy transformation activity | Complete the energy transformation activity in company groups |
| Explain energy output equations for:   * Biomass * Wind * Hydro * Tidal * Solar | Listen and ask clarifying questions |
| Explain energy output worksheets | Complete energy output worksheets individually |
| Explain the summary table and summary graph | Complete the summary table and summary graph in family groups |

# **Accommodations**

Struggling students can be paired with other students while completing the worksheets. If necessary, teacher can adapt numbers to be more student friendly (whole numbers instead of decimals, or double digit numbers as opposed to single digit numbers)

# **Extensions**

Students can do research on Geothermal efficiency and energy output numbers. They can create a short report on why geothermal calculations are not possible at this time.

**Assessment**

The student’s ability to fill out the questions in the power page of the builder’s book demonstrates their understanding of the material. The teacher will use the rubric to evaluate the energy transfer page of the builder’s book and award the “Energy Transfer Certification.”

# **Energy Flow**

To use electronic devices, we must get the power from its source into an accessible form to create electric energy. The power at the source must go through a transformation to end up as electricity in our wall sockets or stored energy in a battery.

**The flow of energy:**

* Primary Energy – the primary source of energy as it exists in the natural environment
* Secondary Energy – the form of energy that is ready for transport
* Final Energy – the energy that you receive (or buy)
* Useful Energy – the energy that is used in your final application

Here are some examples:

|  |  |  |  |
| --- | --- | --- | --- |
| PRIMARY | SECONDARY | FINAL | USEFUL |
| Crude Oil | Petroleum | Gasoline at the gas station | Shaft power for your car wheels |
| Coal | Electricity at the power station | Electricity at your house | Heat from your furnace |

**Student Activity:**

Group the students in their company groups and hand out an Energy Flow Card Deck to each. Have students separate the cards into PRIMARY, SECONDARY, FINAL, and, USEFUL. Then have students arrange to flow of energy for each primary energy.

For an extension, you can have students play a memory game with the cards. Students will flip all cards over in organized rows and columns and pick four cards and try to match them in a working way. This may be easier if three categories are used instead of four.

# **Energy Transformation**

As energy flows from primary to secondary to final to useful, the energy is transformed from one form to another. The source energy has to be converted into something that can be used directly by a consumer. Power plants, refineries, motors, heaters, and stoves are all examples of technologies that convert power from one form to another.

The renewable energy sources that we have discussed convert a fuel (energy source) to useful energy in two different ways:

* Mechanical energy to electrical energy
* Light to electrical energy

Mechanical energy to electrical energy:

* A turbine is a machine designed to use capture the energy of a moving fluid (mechanical energy). As the fluid moves past the turbine blades, the blades rotate and turn an attached shaft. The shaft is connected to a generator. The generator will take the energy of the spinning shaft and convert it to electricity.

Light to electrical energy:

* Light is made up of tiny particles called photons. As light hits a surface, the photons force electrons to be released at an atomic level. This flow of electrons can be captured to produce electricity.

**Student Activity:**

Group the students in their family groups. Based on the research the students did in the energy jigsaw, have them complete the Energy Transformation Worksheet.

Sample answer key:

|  |  |  |
| --- | --- | --- |
| **RENEWABLE SOURCE** | **FUEL** | **TRANSFORMATION** |
| WIND | Wind moving a turbine | Mechanical to electrical |
| HYDRO | Water moving a turbine | Mechanical to electrical |
| TIDAL | Water movement powering a turbine | Mechanical to electrical |
| BIOMASS | Steam from burning fuel powering a turbine | Mechanical to electrical |
| GEOTHERMAL | Steam from hot water powering a turbine | Mechanical to electrical |
| SOLAR | Light from the sun | Light to electrical |

# **Energy Output**

Explanation of efficiency:

All energy transformation systems have a theoretical output and an actual output. The theoretical output represents the output of a perfect system. In the real world, machines do not operate perfectly and the actual output is less than the theoretical output. If a machine is 100% efficient, the actual output will equal the theoretical output. If a machine is 40% efficient, the actual output will be 40% of the theoretical output.

NOTE: Worksheets for each fuel type can be completed individually after each fuel is discussed or all at once after all fuels are discussed – teacher can choose which will work best for his/her class.

**BIOMASS**

The fuel source for a biomass power plant is called the feedstock. The energy output of a biomass plant depends on the thermal energy content of the feedstock (how much energy is created by burning the fuel.

Energy Output Per Day:

**E = 2.8 x TE x m**

* E = energy output per day (kWh)
* TE = thermal energy (MJ/kg)
* m = mass of fuel burned per day (kg)

Efficiency = 30%

Actual Energy Output = E x 0.30

**Student Activity:**

Students will complete this activity alone. Complete the Biomass Energy Worksheet.

Answer key:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **FEEDSTOCK** | **TE**  **MJ/kg** | **m**  **(kg)** | **E**  **(kWh PER DAY)** | **ACTUAL ENERGY OUTPUT**  **(kWh PER DAY)** |
| Corn | 17 | 3 | 142.8 | 42.8 |
| Grasses | 18 | 2 | 100.8 | 30.2 |
| Alfalfa | 17 | 2.5 | 119.0 | 35.7 |
| Wheat straw | 18 | 1.5 | 75.6 | 22.7 |
| Hardwood | 19 | 4 | 212.8 | 63.8 |
| Softwood | 10 | 3.5 | 98.0 | 29.4 |

**WIND**

The power generated from a wind turbine is related to the size of the turbine and the velocity of the wind.

Energy Output Per Day:

**E = 0.015 x A x V3**

* E = energy output per day (kWh)
* A = rotor area (m2)
* V = wind speed (m/s)

The area swept by most wind turbine blades is circular.

Typical rotor area for a home sized wind turbine is 100 m2.

Efficiency = 40%

Actual Energy Output = E x 0.40

**Student Activity:**

Students will complete this activity alone. Complete the Wind Energy Worksheet.

Answer key:

Diameter = 15 meters

Area = 176.7 m2 (note: students need to convert from diameter to radius)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **AREA** | **A**  **(m2)** | **V**  **(m/s)** | **E**  **(kWh PER DAY)** | **ACTUAL ENERGY OUTPUT**  **(kWh PER DAY)** |
| Happy Homestead | 100.0 | 5.4 | 236.2 | 94.5 |
| Value Village | 100.0 | 3.8 | 82.3 | 32.9 |
| Toon Town | 100.0 | 2.5 | 23.4 | 9.4 |
| Silly City | 100.0 | 4.1 | 103.4 | 41.4 |

**HYDRO**

The power output of a hydropower unit is dependent on the head and flow available at the site.

The head is the vertical distance between where the water goes in and where the water goes out.

The flow is the volume of water passing a point at a given time (expressed in cubic feet or cubic meters per second.

Energy Output Per Day:

**E = 9.8 x H x m**

* E = energy output per day (kWh)
* H = head (meters)
* m = flow rate (m3/s)

Efficiency = 50% for a small system

Actual Energy Output = E x 0.50

**Student Activity:**

Students will complete this activity alone. Complete the Hydro Energy Worksheet.

Answer key:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **River** | **Flow (m3/s)** | **Head**  **(m)** | **E**  **(kWh PER DAY)** | **Actual Output**  **(kWh PER DAY)** |
| Raging River – Winter | 3.5 | 2.5 | 86.0 | 43.0 |
| Raging River – Summer | 1.5 | 2.5 | 37.0 | 18.0 |
| Babbling Brook – Winter | 4.0 | 1.2 | 47.0 | 24.0 |
| Babbling Brook – Summer | 2.5 | 1.2 | 29.0 | 15.0 |
| Slippery Stream – Winter | 2.75 | 3.0 | 81.0 | 40.0 |
| Slippery Stream – Summer | 1.25 | 3.0 | 37.0 | 18.0 |

**TIDAL**

The energy output of a barrage tidal system depends on the area of the barrage basin and the vertical tidal range.

Energy Output Per Day:

**E = 2793 x A x h2**

* E = energy output per day (kWh)
* A = horizontal area of the basin (meters)
* h = vertical tidal range (m)

Efficiency = 30%

Actual Energy Output = E x 0.30

**Student Activity:**

Students will complete this activity alone. Complete the Tidal Energy Worksheet.

Answer key:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Tidal Area** | **Area**  **(km2)** | **h**  **(m)** | **E**  **(kWh PER DAY)** | **ACTUAL ENERGY OUTPUT**  **(kWh PER DAY)** |
| Sunny Shore | 0.35 | 3 | 8804 | 2641 |
| Blustery Beach | 0.40 | 5 | 27950 | 8385 |
| Coral Coast | 0.25 | 2 | 2795 | 839 |

**SOLAR**

The energy output of a solar panel installation depends on the area of the panels and the solar radiation that hits those panels.

Energy Output Per Day:

**E = (A x H) / 3300**

* E = energy (kWh)
* A = total solar panel area (m2)
* H = annual average solar radiation (kWh/m2/year)

Average size for a home system is about 20 m2.

Efficiency = 75%

Actual Energy Output = E x 0.75

**Student Activity:**

Students will complete this activity alone. Complete the Solar Energy Worksheet.

Answer key:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **AREA** | **A**  **(m2)** | **H**  **(kWh/m2/y)** | **E**  **(kWh PER DAY)** | **Actual Summer Output**  **(kWh PER DAY)** |
| Happy Homestead – Winter | 20 | 2377 | 14.1 | 10.8 |
| Happy Homestead – Summer | 20 | 4898 | 29.7 | 22.3 |
| Value Village – Winter | 20 | 594 | 3.6 | 2.7 |
| Value Village – Summer | 20 | 7312 | 44.3 | 33.2 |
| Toon Town – Winter | 20 | 5188 | 31.4 | 23.6 |
| Toon Town – Summer | 20 | 5675 | 34.4 | 25.8 |

**GEOTHERMAL**

Geothermal calculations are not included in this lesson. The technology is new and not readily available on a home scale level (not suited to individual users).

# Putting it All Together

**Student Activity:**

Students will complete this activity in their Consulting Companies

Have students fill out the summary table:

* Choose **one** output for each type of energy and compile them in a table.
* Include the household budget total that was calculated in the Power Lesson.

Have the students use the information to create a bar graph.

After table and graph are complete, have the students discuss how and why they think the outputs vary so much between the different sources. Also have them discuss how each source compares to their daily energy consumption.

**Lesson 5: Energy Experiments**

***This is an OPTIONAL lesson to give students hands-on experience seeing the inputs and outputs of various renewable energy technologies***

**Problem Statement**

Before you receive your client story and determine their settlement needs, you investigate how the main sources of renewable energy work. In this lesson, you will perform experiments with the six main renewable energy sources. You will also make and label a diagram of the model and explain how each source works. Sources covered: Solar, Wind, Water, Geothermal, Biomass and Tidal energy.

# **Learning Objectives**

* Students will be able to explain the inputs and outputs for the six renewable energy models provided.
* Students will be able to make a diagram of each model and explain how it works.
* Students will be able to draw the energy transfer process for each renewable source.
* Students will make observations and provide evidence that energy can be transferred from place to place.

# **Standards**

**NGSS 4PS3-2.** Make observations to provide evidence that energy can be transferred from place to place by sound light, heat, and electric currents.

**NGSS 4ESS3-1**. Science and Engineering Principle (SEP) “Obtain and combine information from books and other reliable media to explain phenomena. “

**NGSS 4-PS3-4.** Apply scientific ideas to design, test, and refine a device that converts energy from one form to another

**NGSS 4-PS3-B.** Energy can also be transferred from place to place by electric currents, which can then be used logically to produce motion, sound, heat, or light. The currents may have been produced to begin with by transforming energy of motion into electrical energy

# **Materials**

The geothermal, solar, and biomass experiments will use materials outlined in the NEED Sources of Energy kit experiments (<http://www.need.org/Files/curriculum/guides/ElemScienceofEnergy.pdf>):

* Geothermal - (reference NEED Elementary Science of Energy, Station 2)
  + part 1:
    - baking soda
    - safety glasses
    - measuring cups
    - plastic bags
    - thermometer
    - vinegar
    - timer
  + part 2:
    - calcium chloride
    - measuring cup
    - safety glasses
    - plastic bags
    - thermometer
    - water
    - timer or clock
  + part 3:
    - safety glasses
    - hand warmers
    - plastic bags
    - scissors
    - thermometer
    - sealed plastic bag of iron oxide
    - timer or clock
* Solar - (reference NEED Elementary Science of Energy, Station 3)
  + part 1:
    - 2 thermometers
    - sunlight or light source (incandescent or halogen light bulb)
    - safety glasses
  + part 2:
    - radiometer
    - light source
    - safety glasses
    - piece of black paper
    - piece of white paper
    - two thermometers
    - ruler
  + part 3:
    - solar panel with motor and fan blade
    - light source
    - safety glasses
* Biomass - (reference NEED Elementary Science of Energy, Station 5)
  + part 1:
    - glow sticks
    - 1 cup hot water
    - 1 cup ice water
    - colored pencils
  + part 2:
    - 1 small zinc nail
    - 1 large zinc nail
    - 1 tin wire
    - 1 thick copper wire
    - 1 DC micro-ammeter
    - ruler
    - 1 apple
    - 2 alligator clips
    - permanent marker
    - safety glasses

The wind and hydro experiments will use Thames & Kosmos kits:

* Wind - Thames & Kosmos Wind Power 2.0 experiment kit
* Water - Thames & Kosmos Hydropower experiment kit

The tidal experiment will use the following materials ([Tidal Experiment Materials](http://www.sciencebuddies.org/science-fair-projects/project_ideas/Energy_p028.shtml#materials)):

* Pinwheel (a sturdy pinwheel with a wooden stick works best) or small propeller
* bucket
* water
* Note: the experiment requires various size holes to be drilled in the bottom of the bucket – it is best to have this prepared before doing the experiments with students.

# **Lesson Preparation**

* Review instructions/process for each experiment.
  + NEED Elementary Science of Energy, Station 2
  + NEED Elementary Science of Energy, Station 3
  + NEED Elementary Science of Energy, Station 5
  + Thames & Kosmos Wind Power Experiment Manual
  + Thames & Kosmos Hydropower Experiment Manual
  + [Tidal Experiment Procedure](http://www.sciencebuddies.org/science-fair-projects/project_ideas/Energy_p028.shtml#procedure)
* Gather needed materials:
  + The NEED Sources of Energy Kit can be purchased on the www.need.org website. You can get it for free by attending a free NEED workshop in your area.
  + The Thames & Kosmos kits are approximately $35 each and can be purchased on Amazon.com.
  + Bucket ([5-Gallon Bucket](https://www.lowes.com/pd/Lowes-5-Gallon-Residential-Bucket/3761919)) and a pinwheel for the tidal experiment. ([http://www.sciencebuddies.org/science-fair-projects/project\_ideas/Energy\_p028.shtml#procedure](http://www.sciencebuddies.org/science-fair-projects/project_ideas/Energy_p028.shtml#procedure)))
* Build Wind and Hydro Models and set up the stations.
* Print out experiment directions for each station:
  + Geothermal - NEED Elementary Science of Energy, Pages 61 – 69
  + Solar - NEED Elementary Science of Energy, Pages 72 – 77
  + Biomass - NEED Elementary Science of Energy, Pages 91 – 96
  + Wind – instruction packet in Teacher Resources
  + Water – instruction packet in Teacher Resources
  + Tidal – instructions on <http://www.sciencebuddies.org/science-fair-projects/project_ideas/Energy_p028.shtml#procedure>
* Print handouts required for each experiment.
  + Forms of Energy cards for all stations
  + For all NEED experiments, handouts are included with experiment directions (make sure each group has a copy)
  + Wind Experiment Handout
  + Hydro Experiment Handout
  + Tidal Experiment Handout

# **Time Required**

Two 75 minute class periods:

* First Period: Geothermal, Biomass, and Solar experiments
* Second Period: Wind, Hydro and Tidal experiments

Depending on your class, you may want to do both sessions the same day, or do sessions on consecutive days. The teacher will need to set up the stations with the handouts and give a brief introduction to the process and procedures for each station so that student expectations are clear. It works best if students have 15 minutes to experiment with the station and 5 minutes to clean up so that the station is ready for the next group and fill in their diagrams with energy transfers. The teacher should use a timer to facilitate rotations every 20 minutes

Optional: the teacher can choose to have the students build the Thames & Kosmos wind and hydro kits. This would require another 75 minute class period.

# **Grouping of Students for Instruction**

Students will work in their client groups for the energy flow and energy experiments.

# **Instruction**

|  |  |
| --- | --- |
| **Teacher** | **Student** |
| Teacher will review group norms | Share established norms |
| Teacher will ask students to get into their teams | Move to sit in designated teams and spots |
| **Part One: first three experiment rotations** |  |
| Teacher will briefly introduce the three experiments and procedures for each | Listen and ask clarifying questions |
| Teacher will ask students to turn and talk to a neighbor about the procedures for stations one through three | Turn and talk to a neighbor about what needs to be done at stations one through three. Ask clarifying questions. |
| Teacher will give each team sticks with the numbers 1 through 3 on them to assign group members responsibility for station procedures | Determine which station procedures each group member is responsible for |
| Teacher will remind students to be careful with materials so that there are enough supplies for all teams to get a turn to rotate through all stations | Listen and point to stations where limited supplies may need to be monitored (biomass, geothermal, solar) |
| Teacher will assign students their first station and explain the direction of rotations | Move to the starting station |
| Teacher will start a fifteen minute timer and monitor groups station work | Complete the first experiment |
| Teacher will ask for attention and direct students to clean up and record energy transformations. Start five minute timer | Clean up and record energy transformations |
| Teacher will direct students to rotate, start a fifteen minute timer, and monitor group station work | Rotate station and begin second experiment |
| Teacher will ask for attention and direct students to clean up and record energy transformations. Start five minute timer | Clean up and record energy transformations |
| Teacher will direct students to rotate, start a fifteen minute timer, and monitor group station work | Rotate station and begin third experiment |
| Teacher will ask for attention and direct students to clean up and record energy transformations. Start five minute timer | Clean up and record energy transformations |
| **Part One: second three experiment rotations** |  |
| Teacher will briefly introduce the three experiments and procedures for each | Listen and ask clarifying questions |
| Teacher will ask students to turn and talk to a neighbor about the procedures for stations one through three | Turn and talk to a neighbor about what needs to be done at stations one through three. Ask clarifying questions. |
| Teacher will give each team sticks with the numbers 4 through 6 on them to assign group members responsibility for station procedures | Determine which station procedures each group member is responsible for |
| Teacher will remind students to be careful with materials so that there are enough supplies for all teams to get a turn to rotate through all stations | Listen and point to stations where limited supplies may need to be monitored (biomass, geothermal, solar) |
| Teacher will assign students their fourth station and explain the direction of rotations | Move to the starting station |
| Teacher will start a fifteen minute timer and monitor groups station work | Complete the fourth experiment |
| Teacher will ask for attention and direct students to clean up and record energy transformations. Start five minute timer | Clean up and record energy transformations |
| Teacher will direct students to rotate, start a fifteen minute timer, and monitor group station work | Rotate station and begin fifth experiment |
| Teacher will ask for attention and direct students to clean up and record energy transformations. Start five minute timer | Clean up and record energy transformations |
| Teacher will direct students to rotate, start a fifteen minute timer, and monitor group station work | Rotate station and begin sixth experiment |
| Teacher will ask for attention and direct students to clean up and record energy transformations. Start five minute timer | Clean up and record energy transformations |

Additional Information:

* Geothermal Experiments: Each part of the experiment demonstrates a different type of chemical reaction. Students will be mixing various substances and observing and recording the changes in temperature. Students will identify what type of energy transformation occurred.
* Solar Experiments: Each part of the experiment demonstrates the effects of light (radiant energy). In the first two parts, students will be placing objects in different lighting situations and observing and recording the changes in temperature. In the third part, students will be changing input to a solar panel with a motor and fan blade and recording observations. Students will identify what type of energy transformation occurred.
* Biomass Experiments: Each part of the experiment demonstrates a different type of chemical reaction. Part one uses glow sticks and hot and cold water. Students will be recording the effect of temperature on the brightness of the glow sticks. Part two uses an apple to create an electric current. Students will use a micro-ammeter to measure the current based on different variables. Students will identify what type of energy transformation occurred.
* Wind Experiment: The Thames & Kosmos kit includes instructions for multiple windmills. Students will change variables in the model (blade size, gear ratio) and record results. Students will identify what type of energy transformation occurred.
* Hydro Experiment: The Thames & Kosmos kit includes instructions for multiple waterwheels. Students will change the water flow in the models and record results. Students will identify what type of energy transformation occurred.
* Tidal Experiment: The experiment demonstrates how water flow affects turbine rotation. The students will be letting water flow from a bucket through various size holes and recording the rotations of the windmill (turbine). Students will identify what type of energy transformation occurred.

# **Accommodations**

Teacher can choose the complexity of the wind and water experiments to suit the needs of their students.

# **Extensions**

Teacher can choose the complexity of the wind and water experiments to suit the needs of their students. Purchasing a solar electric house kit would be a great way for students to build a model that is actually powered by solar energy model. Teachers can also print out questions and experiment worksheets from the need Science of Energy book:

* Energy Flow cards pp.108-109
* Science of Energy BINGO p.110 (instructions p.23-24)
* Forms of Energy cards pp.111-113 (key p.25)
* Forms and Sources of Energy p.48 (key p.32)
* Energy Source Matching p.47 (key p.32)
* Energy Crossword p.116 (key p.33)
* Energy Scramble and Energy Transformations p.117 (key p.33)
* Design your own Investigations p. 119
* Glossary of terminology p.120-121

**Assessment**

Formative Assessment in the Lessons - assess if the student correctly identifies the parts of the model and the energy transfer.

* Check to see that student models work
* Model Drawings
* Energy transfer diagrams
* Student explanations of how the renewable energy sources work

**Lesson 6: Energy Requirements**

**Problem Statement**

You will work with your consulting company to determine the needs and wants of you clients. This story will guide your consulting company when considering the accessibility, cost, power source viability, and environmental impact of various settlement locations to help you make the best decision for your clients. Your company will also develop a set of energy requirements and monetary costs of using electrical energy in the house.

**Learning Objectives**

Students will…

1. Work with each other to set a combined list of requirements.
2. Implement the knowledge learned in previous lessons.

**Standards**

**CCSS MATH 4.NBT.** Use place value understanding and properties of operations to

perform multi-digit arithmetic.

**CCSS MATH 4.NF.** Understand decimal notation for fractions, and compare decimal

fractions.

**CCSS MATH 4.MD.** Solve problems involving measurement and conversion of

measurements from a larger unit to a smaller unit.

**CCSS MATH 5.NBT.** Perform operations with multi-digit whole numbers and with

decimals to hundredths.

**CCSS MATH 5.NF.** Apply and extend previous understandings of multiplication and

division to multiply and divide fractions.

**CCSS MATH 5.MD.** Convert like measurement units within a given measurement system.

**Materials**

* Family Story (Each group chooses one out of available stories)
* Family Requirements Packet
  + Family Story Worksheet
  + Energy and Monetary Budget Chart
  + Catalog Handout

**Lesson Preparation**

Print one copy per group of the family story and family requirements packet.

**Time Required**

1 hr

**Grouping of Students for Instruction**

Students will work in their company groups (as described in Lesson 1) to review their client’s energy requirements and budget.

**Instruction**

|  |  |
| --- | --- |
| **Teacher** | **Student** |
| Describe the problem statement for the energy requirements lesson. | Listen. |
| Distribute client’s stories to groups. | Sit quietly. |
| Tell students to read client stories and use close reading to highlight important information. Consider:   * family’s energy needs and wants (highlight color 1) * family’s recreational needs and wants (highlight color 2) * family’s career needs and wants (highlight color 3) | Read family stories and highlight important information. |
| Describe how the group will compromise to select electrical devices for their family’s house (teacher can provide students with some example tools for compromise: take a company vote, create pro and con list). Use the worksheet in the family packet to record the family’s needs and wants. Consider the following questions:   1. If you don’t buy light bulbs, how will you see when it’s dark? 2. If you don’t have a hot water heater, how will you take warm showers? 3. If you don’t buy a clothes washer or dryer, will you wash and dry your clothes by hand? | Listen. |
| Answer questions and facilitate as needed. | Use the family story as a guide and work as a team to decide on the top electrical devices for the client. Fill out the “Item” Column in the Energy and Monetary Budget Chart. |
| Answer questions and facilitate as needed. | For each item in the Energy and Monetary Budget Chart, look in the catalog handout to fill out the “purchase price” column. Calculate the total monetary cost of these devices. Check that the total cost is within budget. |
| Answer questions and facilitate as needed. | Reference the builder’s book for power requirements. Fill out the power column in the energy budget chart for each of the items listed in the Energy and Monetary Budget Chart. |
| Explain to the students that they will use what they learned in the power lesson (and builder’s book) to calculate the total electrical load of the power requirements in their house. | Listen. |
| Answer questions and facilitate as needed. | Use the correct equations from the builder’s book to calculate the electrical load of the family’s house for one year. |
| Collect each team’s Family Requirements Packet. | Sit quietly. |
| Assess each team member’s participation in the project by reviewing completed packets. | Sit quietly. |

**Accommodations**

Students can be given restrictions on the number of electrical appliances allowed in their household. Prices of appliances, electrical load, and power requirements can also be altered to include only single or double digit numbers.

**Extensions**

The family story worksheet is a guide, and students may elaborate on it further. Students can also do their own research to add additional appliances that do not appear in the catalog handout.

**Assessment**

A completed packet serves as the assessment for this lesson.

**Lesson 7: Settlement Proposal**

# **Problem Statement**

The DOE has provided your company with a map of Voltage Valley. Your company will need to determine a location to propose to your clients. The map includes available resources at each plot of land. Use the map and your client's’ story to fill out a Pugh Chart, which will help you determine the best location for your proposal. Be sure to choose a settlement location that falls within your client’s budget and meets their energy requirements.

*Three Part Lesson-*

Part 1: Pugh Chart/Research

Part 2: Proposal Creation

Part 3: Proposal Presentations

# **Learning Objectives**

Students will…

1. Use a map and corresponding resource chart to evaluate different settlement sites.
2. Use a Pugh Chart as a decision making tool.

# **Standards**

**NGSS 4PS3-2.** Make observations to provide evidence that energy can be transferred from place to place by sound light, heat, and electric currents.

**NGSS 4ESS3-1**. Science and Engineering Principle (SEP) “Obtain and combine information from books and other reliable media to explain phenomena. “

**CCSS MATH 4.NBT.** Use place value understanding and properties of operations to perform multi-digit arithmetic.

**CCSS MATH 4.NF.** Understand decimal notation for fractions, and compare decimal fractions.

**CCSS MATH 4.MD.** Solve problems involving measurement and conversion of measurements from a larger unit to a smaller unit.

**CCSS MATH 5. NBT.** Perform operations with multi-digit whole numbers and with decimals to hundredths.

**CCSS MATH 5. NF.** Apply and extend previous understandings of multiplication and division to multiply and divide fractions.

**CCSS MATH 5. MD.** Convert like measurement units within a given measurement system.

[**CCSS.ELA-LITERACY.RI.4.1**](http://www.corestandards.org/ELA-Literacy/RI/4/1/). Refer to details and examples in a text when explaining what the text says explicitly and when drawing inferences from the text.

[**CCSS.ELA-LITERACY.RI.4.2**](http://www.corestandards.org/ELA-Literacy/RI/4/2/)**.** Determine the main idea of a text and explain how it is supported by key details; summarize the text.

[**CCSS.ELA-LITERACY.RI.4.3**](http://www.corestandards.org/ELA-Literacy/RI/4/3/)**.** Explain events, procedures, ideas, or concepts in a historical, scientific, or technical text, including what happened and why, based on specific information in the text.

[**CCSS.ELA-LITERACY.RI.5.**](http://www.corestandards.org/ELA-Literacy/RI/5/2/)**2.** Determine two or more main ideas of a text and explain how they are supported by key details; summarize the text.

[**CCSS.ELA-LITERACY.RI.5.7**](http://www.corestandards.org/ELA-Literacy/RI/5/7/)**.** Draw on information from multiple print or digital sources, demonstrating the ability to locate an answer to a question quickly or to solve a problem efficiently

[**CCSS.ELA-LITERACY.RI.5.8**](http://www.corestandards.org/ELA-Literacy/RI/5/8/)**.** Explain how an author uses reasons and evidence to support particular points in a text, identifying which reasons and evidence support which point(s).

[**CCSS.ELA-LITERACY.W.5.1.A**](http://www.corestandards.org/ELA-Literacy/W/5/1/a/)**.** Introduce a topic or text clearly, state an opinion, and create an organizational structure in which ideas are logically grouped to support the writer's purpose.

[**CCSS.ELA-LITERACY.W.5.1.B**](http://www.corestandards.org/ELA-Literacy/W/5/1/b/)**.** Provide logically ordered reasons that are supported by facts and details.

[**CCSS.ELA-LITERACY.W.5.1.C**](http://www.corestandards.org/ELA-Literacy/W/5/1/c/). Link opinion and reasons using words, phrases, and clauses (e.g., *consequently*, *specifically*).

[**CCSS.ELA-LITERACY.W.5.1.D**](http://www.corestandards.org/ELA-Literacy/W/5/1/d/). Provide a concluding statement or section related to the opinion presented.

# **Soft Skills**

**21st Century Skills: Learning and Innovation.**Learning and innovation skills increasingly are being recognized as the skills that separate students who are prepared for increasingly complex life and work environments in the 21st century, and those who are not. A focus on creativity, critical thinking, communication and collaboration is essential to prepare students for the future.

**21st Century Skills: Life and Career.** Today's students need to develop thinking skills, content knowledge, and social and emotional competencies to navigate complex life and work environments.

# **Materials**

* Map of Voltage Valley
* Site Descriptions Handout
* Settlement Pugh Chart

# **Lesson Preparation**

Print map for each company group or make available electronically. Print class set of Pugh Charts and set of Site Description Handouts.

# **Time Required**

Part 1: 1 Hour

Part 2: 1-2 Hours

Part 3: 1-2 Hours

# **Grouping of Students for Instruction**

Students will work in their company groups (as described in Lesson 1) to determine the best settlement location for their clients

# **Instruction: Part 1**

This is a summary of the activities - details and instructions can be found in subsequent sections.

|  |  |
| --- | --- |
| **Teacher** | **Student** |
| Teacher will describe the problem statement for the settlement proposal research lesson. | Listen. |
| Teacher will distribute maps and pugh charts to groups. | Sit quietly. |
| Teacher will introduce the Pugh Chart and explain its purpose and how to use it. | Sit quietly. |
| Teacher will walk the class through an example family story to demonstrate how to fill out the chart. Use the Pugh Chart alongside a family story to highlight helpful information. (I.e. family needs/wants) | Participate as appropriate. Help the teacher identify the example family’s needs and application to Pugh Chart. |
| Teacher will ask the class facilitating questions for Pugh Chart Exercise:   1. *What are your family's priorities?* 2. *What type of landscape would be ideal for them?* 3. *Are there electronics they can live without? Are there electronic devices your family can’t do without?* 4. *What do you think are your families to priorities (non-negotiables, things they cannot live without)?* 5. *Should certain criteria be weighted?* 6. *Is the highest ranked concept also the best concept for your client?* | Listen and take notes for discussion with group.  Fill out the Pugh Chart using the family story, the map, and the site descriptions. Record the reasons behind each of your decisions. |
| Teacher should walk through the room and help facilitate dialogue between groups. | Use information from the site descriptions to decide the types and amounts of energy that the family will use.  Review all sites using the Family Requirements Packet, revise choices as needed, and make a final site selection.   * Use the “Energy Available” information and decide which types of energy and how much of each they will use. * Calculate cost per day and cost per year for the chosen energy combination. * Revisit the family requirements and compare to the possible site locations. * Revise selections as necessary. * Decide on the one site that will be used for the proposal. |

# **Instruction: Part 2**

|  |  |
| --- | --- |
| **Teacher** | **Student** |
| Teacher will explain that the proposal will be a persuasive writing exercise.   * The student’s consulting firm will be attempting to persuade the family to move to the chosen site in Voltage Valley * Review the key components for the writing exercise (see details below) | Listen and ask clarifying questions |
| Teacher will outline the requirements for the proposal that the students will write. Explain the format and required information for the proposal. | Compile information and write proposal |

# **Part 2: Proposal**

Proposal should be written as a business case that will be presented to the client and the building committee.

Key components for the persuasive writing exercise (writing style):

* INTRODUCTION: Present your point of view - what is the firm’s recommendation?
* REASONS/JUSTIFICATION: Why do you feel this is a good location? How does it meet the needs of the family? If you had to sacrifice any of the family’s needs or wants, how did you prioritize what would be most important to the family? What compromises did you have to make?
* CONCLUSION: Concluding information that reinforces the supporting evidence - restate claim and summarize arguments.

The written proposal should include all of the following information (minimum):

* NAME OF SETTLEMENT
* NAME OF CONSULTING COMPANY
* FAMILY STORY (with energy needs and wants)
* SITE SELECTION
  + Which site was selected
  + Decisions that led to selecting that site (3-4 reasons justifying the selection)
  + How are they going to harness the resources they choose (energy transformation)
* HOW DOES THE LOCATION MEET THEIR OVERALL NEEDS
  + House size
  + Energy available meets or exceeds the family energy requirements
  + Energy choices fit into yearly budget
  + Access to city
  + Access to recreation
  + What compromises did they have to make
* ENVIRONMENTAL IMPACT
  + Will the chosen energy sources leave an impact on the environment
  + How will the environmental impacts be mitigated

# **Instruction: Part 3**

|  |  |
| --- | --- |
| **Teacher** | **Student** |
| Teacher will explain that each group will present their proposal for the rest of the groups to vote on for compliancy. Teacher will explain that each group will need to introduce their family to the group. Talk about the family’s needs and wants in regards to their land in Voltage Valley.  Teacher will also explain that the teams will need to explain what they considered to be important in regards to the Pugh Cart and how it helped them determine a settlement location for their family. The students will be allowed to use their written proposal as a guide for their presentation. In addition to the written support for their proposal the student will need to create a visual representation of their choosing;( examples include a poster, powerpoint, drawing)  Teacher will explain that the rest of the class will be voting on the rubric using the Compliancy Rubrics | Listen and sit quietly.  Students will follow along and participate as needed. |

# **Part 3: Presentation**

Explain expectations for oral presentation:

* Explain that rest of class will be voting on the proposal
* Teams will introduce their family and talk about the family’s interests
* Teams will explain what they considered and how they used the Pugh chart to help them determine a settlement location for their family
* Teams will explain how they determined their final settlement location and make a pitch for why this location is the best one for the family
* Visual presentation: examples include a poster, powerpoint, drawing

Explain that rest of class will be voting on the proposal

* Create student worksheet from rubric
* Students will follow along as the presentations are given

# **Accommodations**

Students can be provided with a template with sentence stems to create their rough draft. Students can also be provided with fewer land plot options for their pugh chart activity.

# **Extensions**

Consider seasonal changes in available resources.

# **Assessment**

Students will be assessed on their final proposal and on their group presentation. There will also be a peer review component.

Collaboration will be assessed by the teacher using the BIE CCSS Collaboration Rubric.

The final presentation will be assessed by the teacher using the Homestead Proposal Rubric.

The students will act as council members during the oral presentation and peer review each other using the Council Member Rubric.